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Cheng F. Lee
Chunchi Wu
Mohamed Djarraya

College of Commerce and Business Administration
Bureau of Economic and Business Research
University of Illinois, Urbana-Champaign

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Cheng F. Lee, Professor
Department of Finance

Chunchi Wu
Syracuse University

Mohamed Djarraya
Gestion Sfax Tunisia

ABSTRACT

Based upon the finance theory and modern econometric methods, an integrated dividend adjustment model consistent with the practical decision process is proposed. It is analytically demonstrated that the residual theory, partial adjustment and adaptive expectations models are all special cases of the integrated model specified in this paper. Marquardt's non-linear regression method is adopted to estimate the parameters of the integrated model, using both quarterly and annual data of earnings and dividends from eighty randomly selected industrial companies. Empirical results show that the integrated model better explains the firm's dividend decision process.

A Further Empirical Investigation of the Dividends Adjustment Process

The residual theory (Higgins [10]), partial adjustment model (Lintner [15], Fama and Babiak [8]) and information content model (Pettit [21], Laub [13], Watts [26] and Ang [1]) are commonly used to explain the firm's dividend adjustment process. The residual theory holds that firms should finance as many acceptable investment projects as possible with equity capital since internal financing is cheaper than external financing. Dividends are therefore a residual that reflects the amount left over from earnings after investment projects are financed by equity capital. In contrast, proponents of the partial adjustment model maintain that firms usually establish a desired level of dividend payout and gradually adjust the current level of dividends to the desired level. The length of adjustment lag depends on the extent of institutional rigidities. The supporters of the information content hypothesis take an alternative view of dividend policy. They suggest that dividends convey information about future earnings expected by management. One version of the information content hypothesis is represented by the adaptive expectation model that specifies the formation of expectations in a consistent manner.

As with any models involving the firm's decisions one might ask how well the above dividend models are consistent with observed behavior. Formal tests on the consistency of these models requires formulating a cohesive model which permits inclusion of competing hypotheses. However, so far there has been lack of such work that aims at deriving this type of model.

In this paper, we attempt to fill this gap by deriving a general model that includes the above three competing hypotheses as special cases. The proposed model is motivated by Doran and Griffiths [6]. The model developed

can be used to test whether the firm's dividend decision follows either or some combination of the above three hypotheses. The remainder of the paper is divided into five sections. Section I briefly reviews and compares the partial adjustment model and the adaptive expectations model as a specification for the information content hypothesis. Section II proposes a generalized model which incorporates the competing hypotheses of dividend adjustment process and suggest possible ways to identify firm's dividend behavior. Section III discusses the estimation method used to obtain the structural coefficients of the proposed model. Section IV describes data and provides empirical tests on alternative dividends adjustment hypotheses. Section V summarizes the important findings.

I. Partial Adjustment versus Adaptive Expectations

In this section, we briefly compare and contrast the partial adjustment and adaptive expectations models with respect to their basic assumptions and model specification. Following this, we discuss several important empirical implications of these two models.

A. Partial adjustment model

The partial adjustment model proposed by Lintner can be characterized as

(1) $$\bar{D}_t = rE_t$$

and

(2) $$D_t - D_{t-1} = \alpha + \lambda(\bar{D}_t - D_{t-1}) + u_t$$

Equation (1) indicates that the firm's desired dividend payment $\bar{D}_t$ is determined by the net income E_t of the current period and the target payout ratio r. Equation (2) states that the level of dividend payments will move only partially from the starting position D_{t-1} to the desired position $\bar{D}_t$ when net

income E_t increases to a new level. The move depends on the confidence of management in maintaining the new higher level of dividends. Thus a change of dividends between time t and time t-1 would be equal to $\lambda(\bar{D}_t - D_{t-1})$ instead of $(\bar{D}_t - D_{t-1})$. The parameter λ is the speed of adjustment coefficient, and $(1-\lambda)$ is called the safety factor. λ can be expressed as a function of the firm's investment opportunities, investors' preferences, marginal income tax rates, transaction costs, etc. The constant term α in equation (2) was added by Lintner to test whether managers are more reluctant to cut dividends than to raise them. This constant is postulated to be positive. Finally, u_t is the error term.

Substituting (1) into (2) yields

(3) $$D_t - D_{t-1} = \alpha + r\lambda E_t - \lambda D_{t-1} + u_t$$

Empirical studies by Brittain [4] and Fama and Babiak [8] have indicated that equation (3) fitted the aggregate and the individual company data very well and produced only small mean squared prediction errors. The coefficients of earnings and lagged dividends were significant. Furthermore, the R^2 value did not significantly increase when other financial variables were added. However, a problem of this model arises from the postulation that the desired dividend payment is dependent upon the current instead of long-run expected net income. This assumption may not be appropriate for companies with income severely fluctuating from period to period. Harkins and Walsh's [9] study shows that expectation of future net incomes is considered as a very important factor of dividend decisions by most financial managers.

B. Adaptive expectations model

In contrast to the partial adjustment model, the adaptive exectations model hypothesizes that current dividends are related to the expected future

net income. This relationship can be expressed as

(4) $$D_t = rE_t^* + \varepsilon_t$$

where D_t, E_t^* and r are the current dividends, expected long run income and target payout ratio, respectively, and ε_t is a error term. Thus, current dividends D_t can be decomposed into the permanent component (rE_t^*) and the transitory component (ε_t). The former is dependent upon management's expectation of long-run income. The latter could be a nonrandom transitory dividend component decided by the firm or possible errors due to data (D_t) measurement, misspecification for (4) and poor forecasting for E_t and r in any time period t.

The expected income is not directly observable. To determine the expected income, Nerlove [19], and Ball and Watts [2] assumed that

(5) $$E_t^* - E_{t-1}^* = \delta(E_t - E_{t-1}^*)$$

or equivalently,

(5a) $$E_t^* = \delta E_t + (1 - \delta)E_{t-1}^*$$

where δ, the coefficient of expectations, is the proportion of the expectational error taken to be permanent rather than transitory (see Waud [27]). Expectations are updated each period by a fraction of the discrepancy between the current observed income and the previous expected income. More specifically, the expected or permanent value of E_t at time t is represented by a weighted average of the current income and the income expected in the preceding period. Such a formation of expectations is based on the idea that current expectations are derived by modifying previous expectations in the light of the current income.

Recursively substituting the values of E_{t-1}^*, E_{t-2}^*, ..., and E_{t-s}^* into the right hand side of equation (5a) gives

(5b) $$E_t^* = \delta[E_t + (1 - \delta)E_{t-1} + (1 - \delta)^2E_{t-2} + \dots + (1 - \delta)^sE_{t-s}]$$

Substituting (5b) into equation (4) yields

(6) $$D_t = r\delta[E_t + (1 - \delta)E_{t-1} + \ldots + (1 - \delta)^s E_{t-s}] + \varepsilon_t$$

Using Koyck transformation, equation (6) can be simplified as

(7) $$D_t - D_{t-1} = r\delta E_t - \delta D_{t-1} + \varepsilon_t - (1 - \delta)\varepsilon_{t-1}$$

Although equation (7) differs from equation (3) only in the constant and disturbance terms, the nature of the adjustment process should be recognized in interpreting the coefficients. The λ in equation (3) is the speed of adjustment while the δ in equation (7) is the profit expectation coefficient. Further, the adaptive expectations model attributes the lags to uncertainty and the discounting of current information, whereas the partial adjustment model attributes these lags to technological, institutional and psychological inertia, and the increasing cost of rapid change.[1]

Studies by Solomon [24], Laub [13] and Pettit [21, 22] indicated that dividends convey information about future earnings prospects and that change in dividends is a result of change in the expectations of long run earnings. More importantly, Ang has shown that the short run dividend payout is consistent with the adaptive expectations hypothesis while the long run dividend payout generally supports the partial adjustment hypothesis. Ang's work suggests a possibility to formulate a generalized model to explain the dividend behavior in the short, intermediate and long run. In the following section, we propose a generalized model integrating both adaptive expectations and partial adjustment hypotheses.

II The Integrated Model

Assume that the desired dividends are determined by the expected income as

(8) $$\bar{D}_t = rE_t^*$$

Further, assume that the formulations in equations (2) and (5) hold. Note that equation (4) is bypassed. With these assumptions, it is now possible to embody both adaptive expectations and partial adjustment hypotheses into a more general framework. Combining equations (2), (5a), (5b) and (8) gives

$$D_t = \alpha + \lambda r\delta[E_t + (1-\delta)E_{t-1} + (1-\delta)^2 E_{t-2} + \ldots \\ \ldots + (1-\delta)^s E_{t-s}] + (1-\lambda)D_{t-1} + u_t \tag{9}$$

Following Lintner [15] and Doran and Griffith [6], the disturbance u_t in equation (2) is preserved. Equation (2) is usually regarded as the common place to introduce the disturbance term since the actual dividend D_t is stochastic and the desired dividend $\bar{D}$ is deterministic. Also, it is assumed that the expectations are continually formed in a consistent manner as in [6]. If this assumption is violated then an additional error term would be needed in equation (8).

Equation (9) can be simplified by using the Koyck transformation so that

$$D_t - D_{t-1} = \alpha\delta + (1-\lambda-\delta)D_{t-1} - (1-\delta)(1-\lambda)D_{t-2} \\ + r\lambda\delta E_t - (1-\delta)u_{t-1} + u_t \tag{10}$$

Equation (10) states that current dividends are determined by current net income and dividends in the last two periods.[2] Using this equation, we can test several hypotheses listed in Table 1. We see that partial adjustment and adaptive expectations are merely special cases of equation (10).

Rewrite equation (10) as

$$D_t = a_1 + a_2 D_{t-1} - a_3 D_{t-2} + a_4 E_t + v_t \tag{11}$$

where

$$a_1 = \alpha\delta;\ a_2 = (2-\lambda-\delta);\ a_3 = (1-\lambda)(1-\delta);\ a_4 = r\lambda\delta;$$

and

$$v_t = u_t - (1-\delta)u_{t-1}.$$

Table 1

Alternative Hypotheses

	Hypothesis	Statistical test
1.	Partial adjustment process	$\delta = 1$
2.	Information content or adaptive expectations	$\lambda = 1$
3.	Myopic dividend policy*	$\lambda = 1$ and $\delta = 1$
4.	Residual dividend policy	$\lambda = 1$, $\delta = 1$, and $r = 0$

*With this policy current dividends are based solely on current earnings.

This is a regression model with nonlinearities in the parameters. Moreover, if u_t is normal, identically and independently distributed, and δ is not equal to one, v_t will be serially correlated. Under these circumstances, it can be demonstrated that ordinary least squares estimators are inconsistent, and that the structural regression coefficients, α, δ, λ, and r can be identified, but can not be estimated due to the unobservable u_t. On the other hand, if v_t is normal and independently distributed, then δ and λ can not be identified. To obtain consistent and unique estimates of the structure parameters, we adopt a nonlinear regression method combined with the maximum likelihood technique proposed by Zellner and Geisel [29] and Park [20]. In the following section, the estimation procedure is described.

III Estimation Procedure

Marquardt's [17] nonlinear least squares regression method was used to estimate the structural parameters of equation (11). As indicated in Draper and Smith [7], this method combines the basic features of both the steepest descent and Gauss-Newton methods. Also, we have found that Gauss-Newton procedure converges very slowly for some firms included in the data set. For these reasons, we have chosen Marquardt's method to estimate the coefficients of the nonlinear regressions.[3]

As with any nonlinear regression methods, the selection of initial parameter values is important. The initial estimates of the parameters were obtained from the maximum likelihood method suggested by Zellner and Geisel. Their procedure contains two steps. The first step is to estimate the δ value which maximizes a log-likelihood function. The second step involves estimating the structural parameters. Details of the procedure are described in the Appendix.

A crucial element in the regression model is the disturbance term. If u_t is normal and independently distributed and δ is not equal to one, v_t is serially correlated. Alternatively, if u_t follows a first order serial correlation, v_t is normally distributed only if $\rho = (1-\delta)$. Otherwise v_t follows an ARMA (1,1) process.[4] As shown in the Appendix, we consider both cases for u_t (with and without serial correlation) in estimating the regression coefficients.

IV Empirical Results

Quarterly and annual earnings and dividends were obtained from the Compustat tape for the period 1962-78. Earnings and dividends per share were adjusted for stock splits. The original data set was restricted to those firms which met the following three requirements: (1) the fiscal year ends in December; (2) there are no missing values for dividends and earnings during the study period; (3) firms are not subject to any government regulation. The last requirement excludes utility and financial companies from the original data set. In all, 889 firms met the three requirements. A random sample of 80 industrial firms was selected primarily for the consideration of computing cost.[5] Firms were selected using the random number table. Examination of data using the X-11 program developed by Shiskin, Young and Musgrave [23] reveals that seasonality exists in the quarterly data of 65 companies. Hence, quarterly data were seasonally adjusted by the procedure suggested by Shiskin et al.[6]

Table 2 summarizes the cross-sectional distribution of parameter estimates, the sum of squared residuals and R^2 under the assumption that u_t is serially uncorrelated. The mean of target payout ratio, r, is equal to .435; and the standard error of the mean is .303. The dispersion as measured by the

Table 2

Cross-sectional Distribution of Nonlinear Regression Results
When u_t is Serially Independent

	r	$t(r)$	α	$t(\alpha)$	λ	$t(\lambda)$	δ	$t(\delta)$	SSR	R^2
Mean	.435	5.923	.036	1.510	.478	4.411	.232	2.718	.116	.864
Standard Error	.303	.516	.010	.216	.039	.291	.031	.235	.059	.091
Standard Deviation	.270	4.616	.091	1.940	.353	2.605	.281	2.110	.533	.815
Semi-interquartile	.124	2.862	.019	1.288	.288	1.521	.102	.887	.021	.025
Fractiles										
.10	.170	.854	-.019	-.873	.113	1.848	.032	.979	.001	.832
.20	.233	2.449	-.003	-.272	.186	2.566	.044	1.397	.002	.909
.30	.292	3.014	.003	.491	.253	2.813	.060	1.629	.005	.964
.40	.338	3.681	.007	.871	.305	3.363	.080	2.050	.008	.970
.50	.370	4.034	.014	1.338	.375	3.962	.116	2.340	.017	.984
.60	.450	4.983	.020	1.915	.456	4.261	.160	2.903	.024	.989
.70	.485	7.772	.033	2.607	.558	4.754	.218	3.095	.038	.991
.80	.570	8.996	.052	3.044	.739	6.360	.347	3.373	.072	.993
.90	.677	11.966	.143	3.803	.992	7.261	.678	4.013	.215	.995

Notes:

1. The mean, various measures of dispersion of regression coefficient estimates, t statistics, the sum of squared residuals (SSR) and R^2 are reported.
2. All data were seasonally adjusted.

standard deviation of the distribution is equal to .27. The distribution of estimated target payout ratios ranges from .17 for the .10 fractile to .677 for the .90 fractile.

The relationship between the desired dividend per share and the expected earnings per share is very strong for more than 80% of the firms in the sample. The .20 fractile of t values for the estimated target payout ratios is 2.449 and the .90 fractile is equal to 11.966. The distribution of the t values of the estimated target payouts has a mean of 5.923 and a median of 4.034. This suggests that expected earnings, instead of current earnings are an important factor that determines desired dividends.

The constant term α, is not always positive as stipulated by Lintner. Nevertheless, more than 70% of the firms have a positive constant term and at least 30% of the firms have a significantly positive constant terms. The mean of the distribution is .036 and the median .014.

The distribution of the estimated speed of adjustment coefficient, λ, indicates that most firms have a coefficient between zero and one as expected. The mean of the distribution is .478, which suggests that the adjustment generally takes two periods (quarters) to complete. The .10 fractile is .113 and the .90 fractile is .992. Furthermore, this coefficient is significantly different from zero for more than 80% of the firms in the sample. The .20 fractile for the t values is 2.556 and the .90 fractile is 7.261.

Similarly, the estimated coefficients of expectations, δ, are within the expected interval and of the expected sign. The mean coefficient of expectation is .232 and standard deviation .281. The average t value is 2.718. Nevertheless, at least 30% of the firms have a δ value not significantly different from zero. Finally, the R^2 values are generally high with an average of .864.

Table 3 shows the cross-sectional distribution of estimated parameters assuming that u_t is serially dependent. The autoregressive coefficient, ρ, is generally negative, with mean equal to -.104. The .10 fractile is -.398 and the .80 fractile is -.021. However, this negative relationship is not strong. The mean of the t values of the estimated autocorrelation coefficient is only -.607 and the .20 fractile is -1.886. Therefore, less than 20% of the firms have an autocorrelation coefficient significantly different than zero. The Durbin-Watson statistics reported in the last column show very little sign of first order correlation.

The rest of the estimated parameters appear not much changed by the autoregression. The mean target payout ratio remains around .434 and is significantly different from zero. The intercept term has positive sign, though often insignificant, for more than 70% of the firms. The intercept averages .03 and its t value averages only .979. The mean adjustment and expectation coefficients are .441 and .275 respectively with significant average t values.

The results indicate that in general neither the partial adjustment model nor the adaptive expectations model can completely explain the dividend behavior of industrial firms. The constant term appears not significantly different from zero. Finally, the autocorrelation coefficients of u_t are generally negative but not strong.

To provide further information on dividend behavior, we next classify companies into four groups according to the parameter estimates in Table 3, and examine the behavior of different company groups. Group one contains the companies whose dividend behavior was explained by the integrated model, that is, the estimates of both adjustment and expectation coefficients are significantly different from, but fall between, zero and one. Group two consists of

Table 3

Cross-sectional Distribution of Nonlinear Regression Results
When u_t is Serially Dependent

	r	$t(r)$	α	$t(\alpha)$	λ	$t(\lambda)$	δ	$t(\delta)$	ρ	$t(\rho)$	SSR	R^2	DW
Mean	.434	5.538	.030	.979	.441	2.548	.275	2.427	-.104	-.607	.108	.865	2.208
Standard Error	.025	.506	.008	.146	.039	.146	.040	.204	.029	.196	.052	.091	.058
Standard Deviation	.228	4.530	.007	1.306	.356	1.314	.364	1.829	.263	1.756	.473	.814	.526
Semi-interquartile	.121	2.761	.018	.957	.250	.413	.132	.799	.172	.922	.021	.025	.344
Fractiles													
.10	.201	.786	-.016	-.743	.105	1.438	.031	.786	-.398	-2.358	.001	.833	2.796
.20	.246	2.376	-.001	-.252	.133	1.742	.049	1.290	-.330	-1.886	.002	.910	2.660
.30	.310	2.860	.001	.244	.202	1.995	.069	1.474	-.267	-1.420	.005	.968	2.534
.40	.336	3.329	.004	.628	.249	2.132	.084	1.811	-.197	-1.119	.008	.978	2.349
.50	.400	3.766	.011	.867	.314	2.263	.106	2.026	-.149	-.713	.015	.985	2.298
.60	.445	4.685	.018	1.472	.397	2.521	.181	2.466	-.096	-.427	.023	.987	2.192
.70	.492	6.046	.026	1.776	.573	2.608	.213	2.734	-.021	-.076	.037	.992	2.042
.80	.570	8.803	.044	2.101	.696	2.846	.413	3.135	.093	.357	.070	.995	1.814
.90	.721	12.552	.115	2.467	1.078	3.695	.815	3.658	.227	.792	.212	.998	1.546

Notes:

1. The mean, various measures of dispersion of regression coefficient estimates, t statistics, autocorrelation parameter (ρ), sum of squared residuals (SSR), R^2 and Durbin-Watson statistics are reported.
2. All data were seasonally adjusted.

companies whose dividends behavior can be explained by the adaptive expectations models, or equivalently, whose dividend adjustment coefficients are notsignificantly different from one and expectation coefficients are significantly different from zero. Similarly, group three includes companies that have dividend adjustment coefficients significantly different from zero and expectation coefficients not significantly different from one. A five percent significance level was used in grouping the companies. The rest of the companies are included in group four. We use model names to distinguish these groups.

Table 4a indicates the number of companies, the mean and standard deviation of estimated structural parameters for each group. Table 4b tabulates the t statistics with respect to the null of λ or δ equal to one. We used the analysis of variance (ANOVA) technique to test the difference of structural parameters among four groups. We found that three parameters, α, λ, and δ are significantly different among four groups at five percent significance level. However, the target payout ratios appear not significantly different.

We also used annual data for the same companies to estimate the structural parameters. The results appear similar to what we have found in Tables 2 to 4, though the proportions of parameter estimates which are significantly different from zero at five percent significance level drop slightly. Since there is no additional information involved, the empirical results for annual data are not reported here.[7]

The characteristics of the firms in each group were examined. We first looked at the individual firms' payout pattern. Assuming the group payout ratio is the target payout pattern, we examined the deviations of individual firms' payout ratios from the target. We found 29 firms whose payout ratios are significantly different from the target ratios. Among them, 14 firms are

Table 4a

Mean and Standard Deviation of the Estimated Structural Parameters For Different Dividend Behavioural Models

Group	Parameters				Number of Companies
	r	α	λ	δ	
1. Integrated model	.378 (.225)	.031 (.065)	.445 (.154)	.121 (.069)	25
2. Adaptive expectation model	.476 (.288)	.082 (.148)	1.060 (.272)	.082 (.068)	19
3. Partial adjustment model	.442 (.451)	.008 (.019)	.139 (.112)	.931 (.176)	11
4. Other	.478 (.191)	.012 (.048)	.214 (.098)	.201 (.168)	25
Overall sample	.435 (.270)	.036 (.091)	.478 (.353)	.232 (.281)	80

Notes:

1. The numbers in parentheses are the standard deviations of the estimated coefficients in each group.
2. The parameters are from the regressions which assume u_t is serially independent.

Table 4b

Cross-Sectional Distribution of t Statistics Associated with Partial Adjustment and Adaptive Expectation Coefficients*

	$t(\lambda)$	$t(\delta)$
Mean	- 7.976	-28.118
Standard Error	1.357	3.622
Standard Deviation	12.143	32.395
Semi-interquartile	2.981	17.779
Fractile		
.10	-15.815	-71.830
.20	-10.538	-46.044
.30	- 8.475	-33.733
.40	- 7.083	-25.665
.50	- 6.099	-17.611
.60	- 4.900	-13.068
.70	- 3.811	- 6.821
.80	- 1.974	- 3.029
.90	- .052	- 1.538

*The t statistics with respect to the null of λ or δ equal to unity are reported.

from group 1, 7 firms from group 2, 3 firms from group 3, and 5 firms from group 4. In terms of percentage, this is equivalent to 56 percent of the companies in group 1, 36.8 percent in group 2, 27.2 percent in group 3 and 20 percent in group 4. The higher proportion of deviations in group 1 (integrated model) may reflect the unique dividend adjustment process of this group. Since the firms in group 1 have both lags in adjusting actual dividend payments (partial adjustment) and earnings expectations (adaptive expectations), we may expect them to have greater difficulties to adjust toward the target (group) payout ratio. We also found that the earnings volatility is relatively higher for the group of adaptive expectations. The average values of the standard deviations of current earnings are .35, .67, .19 and .40 for each group, respectively. This may explain why the adjustment of earnings expectations is not instantaneous for group 2. Presumably, earnings volatility is associated with random fluctuation of short term earnings. Therefore, managers will be more cautious in adjusting their expectations on earnings. Furthermore, we checked the size, operation characteristics and industry type of the firms and found no unique pattern for each individual group. Each group contains firms with different size, operation characteristics and from a very wide range of industries. Therefore, it is less likely that firm's dividend policy will be affected by these factors.

The results in Tables 2 and 3 were obtained under the assumption that the disturbance term u_t is either independent or following a first order serial correlation. In reality, firms may adopt a practice of a fourth quarter balloon dividend the size of which depends on current or expected earnings. The existence of the fourth order serial correlation could produce incorrect estimated standard errors and affect the statistic testing results. To examine this particular problem the fourth order serial correlation was

Table 5

Summary Statistics of the Fourth Order Autocorrelation

	ρ_4	$t(\rho_4)$
Mean	.186	1.630
Standard Error	.032	.297
Standard Deviation	.290	2.662
Semi-interquartile	.114	.986
Fractiles		
.10	-.052	-.359
.20	-.011	.086
.30	.005	.042
.40	.059	.448
.50	.092	.725
.60	.122	.965
.70	.173	1.329
.80	.364	2.661
.90	.633	4.927

checked. Table 5 displays the summary statistics of the fourth order autoregressive coefficients ρ_4. The autoregressive coefficients are generally positive. There are 21 firms that have significant fourth order autoregressive coefficients. However, for most of the firms examined, the sizes of the autoregressive coefficients are fairly small. Similar to the results for the first order serial correlation reported in Table 3, we also found that the nonlinear regression estimates are in general not sensitive to the treatment of the fourth order autocorrelation.[8]

To provide additional information on the dividend behavior of the firms in different groups, we re-estimated the four models as indicated in Table 4 using the pooled cross-section and time series data in each group. The use of cross-section time series regression method would increase the efficiency of the estimators. The cross-section time series coefficient estimates are reported in Table 6.[9] Note that the number of observations for each group increases substantially (66 times the number of firms in each group). This greatly increases the estimation efficiency. As shown in the table, all the coefficients are significant at one percent level. However, it is interesting to note that the sizes of lagged dividends coefficients vary across different models. In particular, the coefficient of D_{t-2} for the integrated model is much larger than that for the other models. This is consistent with the hypothesis of the generalized model. If either δ or λ is close to one, the coefficient of D_{t-2} will be close to zero. Moreover, the coefficient of D_{t-1} is relatively smaller for the integrated model. The likelihood ratio tests were also performed with the restriction of D_{t-2} coefficient equal to zero for all four models and an additional restriction of D_{t-1} coefficient equal to zero for the "other" model. The F statistics are all significant at the one percent level. Thus, the restricted models are significantly different from

Table 6

Results of the Pooled Cross-Section Time Series Regressions

	Constant	D_{t-1}	D_{t-2}	E_t	F
Integrated model					
	.016	.445	.432	.035	
	(4.57)	(20.95)	(20.41)	(16.72)	
	.039	.823		.038	1044.52
	(8.28)	(75.34)		(19.72)	
Adaptive expectation model					
	.033	.528	.177	.098	
	(6.03)	(21.08)	(7.11)	(21.25)	
	.041	.676		.102	11.03
	(7.63)	(45.10)		(22.92)	
Partial adjustment model					
	.006	.617	.330	.012	
	(1.91)	(22.94)	(12.75)	(5.47)	
	.008	.925		.018	155.22
	(2.94)	(80.04)		(7.85)	
Other	.007	.793	.154	.014	
	(4.20)	(33.39)	(6.52)	(9.87)	
	.006	.949		.015	59.30
	(4.36)	(155.98)		(10.18)	
	.282			.010	13501.30
	(111.84)			(7.12)	

Notes:

1. The t values of the estimated coefficients are included in the parentheses.
2. F values associated with testing the linear restrictions are reported in the last column. All F statistics are significant at the one percent level.

the unrestricted models. The overall results strongly support the contention that the integrated model is more suitable for examining the dividend adjustment process. The difference between the results of nonlinear regressions and cross-section time series regressions may reflect that pooled (group) data are used in the latter estimation. The results, therefore, suggest that for the group or aggregate data such as in Lintner [15] and Fama and Babiak [8], the integrated model should better explain the firms' dividend adjustment over time.

V Summary

In this paper, we propose an integrated model to investigate the dividend behavior of industrial firms. We have analytically shown that the traditional dividend models as represented by the partial adjustment model, information content hypothesis, and residual theory are all special cases of the integrated model derived in this paper. Thus, the proposed model provides a more flexible framework for examining the dividend adjustment process.

Based on quarterly and annual earnings and dividend data for a random sample of 80 industrial companies, we estimated the structural parameters using Marquardt's nonlinear regression method. The model is effective in explaining individual firm's dividend behavior. We have found that firm's dividend adjustment process can be better identified by the proposed integrated model.

Appendix

Following Zellner and Giesel [29] and Park [20], we express equation (10) as

$$\text{(A.1)}\quad D_t - u_t = \alpha\delta + (1-\lambda)D_{t-1} - (1-\lambda)(1-\delta)D_{t-2} + r\lambda\delta E_t + (1-\delta)(D_{t-1}-u_{t-1}).$$

Assume $w_t = D_t - u_t$ and u_t is normally, identically and independently distributed. Rewrite (A.1) as

$$w_t = \alpha\delta + (1-\lambda)D_{t-1} - (1-\lambda)(1-\delta)D_{t-2} + r\lambda\delta E_t + (1-\delta)w_{t-1}.$$

By recursive substitution for w_t we get

$$\begin{aligned}\text{(A.2)}\quad w_t = {} & (1-\lambda)[D_{t-1} + (1-\delta)D_{t-2} + (1-\delta)^2 D_{t-3} + \ldots] \\ & -(1-\lambda)[(1-\delta)D_{t-2} + (1-\delta)^2 D_{t-3} + (1-\delta)^3 D_{t-4} + \ldots] \\ & + \alpha[\delta + \delta(1-\delta) + \delta(1-\delta)^2 + \ldots] \\ & + r\lambda[\delta E_t + \delta(1-\delta)E_{t-1} + \delta(1-\delta)^2 E_{t-2} + \ldots] \\ & + w_0(1-\delta)^t\end{aligned}$$

or

$$w_t = (1-\lambda)Z_{t1} - (1-\lambda)Z_{t2} + \alpha Z_{t3} + r\lambda Z_{t4} + w_0 Z_{t5}$$

where

$$Z_{t1} = \sum_{i=1}^{t} (1-\delta)^{i-1} D_{t-i}$$

$$Z_{t2} = \sum_{i=1}^{t} (1-\delta)^{i} D_{t-i-1}$$

$$Z_{t3} = \sum_{i=1}^{t} \delta (1-\delta)^{i-1}$$

$$Z_{t4} = \sum_{i=1}^{t} \delta (1-\delta)^{i-1} E_{t-i+1}$$

$$Z_{t5} = (1-\delta)^t .$$

Rewrite equation (A.1) as

$$\text{(A.3)}\quad D_t = (1-\lambda)(Z_{t1} - Z_{t2}) + \alpha Z_{t3} + r\lambda Z_{t4} + w_0 Z_{t5} + u_t.$$

The logarithmic likelihood function of $D_1, D_2, \ldots, D_n$ is

$$\text{(A.4)} \qquad L = \frac{n}{2}\log(2\pi\sigma_u^2) - \frac{1}{2\sigma_u^2}\sum_{t=1}^{n}[D_t - (1-\lambda)(Z_{t1}-Z_{t2}) - \alpha Z_{t3} - r\lambda Z_{t4} - w_0 Z_{t5}]^2.$$

Maximizing L with respect to r, α, γ, δ and w_0 is equivalent to minimizing

$$\text{(A.5)} \qquad S^{(\delta)} = \sum_{t=1}^{n}[D_t - (1-\lambda)(Z_{t1}-Z_{t2}) - \alpha Z_{t3} - r\lambda Z_{t4} - w_0 Z_{t5}]^2$$

with respect to the same parameters. Since δ is theoretically between zero and one, the minimizing values of $(1-\lambda)$, α, $r\lambda$, and w_0 and the corresponding value $S^{(\delta)}$ can be easily calculated for different values of δ from 0 to .99. Then, the values of $(1-\lambda)$, α, $r\lambda$, and w_0 that lead to the smallest value of $S^{(\delta)}$ are selected. These values will be the maximum likelihood estimates of the respective parameters. The standard error of these parameters can be estimated by taking the square roots of the main elements of the inverse of the appropriate information matrix. Note that it is the asymptotic standard errors which are being derived from the estimated information matrix. Therefore, all these tests are more suitable for a large sample.

Following the same procedure, we can derive the condition of maximizing the logarithmic likelihood function when u_t is serially dependent. It can be easily shown that maximizing the logarithmic likelihood function is equivalent to minimizing

$$\text{(A.6)} \qquad S^{(\delta,\rho)} = \sum_{t=1}^{n}[D_t(\rho) - (1-\lambda)(Z_{t1}(\rho)-Z_{t2}(\rho)) - \alpha Z_{t3}(\rho) - r\lambda Z_{t4}(\rho) - w_0(\rho)Z_{t5}]^2.$$

where

$$D_t(\rho) = D_t - \rho D_{t-1}$$

$$Z_{ti}(\rho) = (Z_{ti} - \rho Z_{t-1,i}),\ i = 1 \text{ to } 5,$$

and

$$w_0(\rho) = w_0 - \rho w_{-1}.$$

The minimizing values of r, λ, α, and δ in equations (A.5) and (A.6) were used as the initial values of nonlinear regressions that yield the results in Tables 2 and 3.

Footnotes

[1]The partial adjustment model defined in equations (1) and (2) implies that desired dividend payments are a function of current earnings and adaptive expectations model defined in equations (4) and (5) implies that the current period dividend payments are a function of long-term expected earnings and a disturbance term. Both of them can be used to develop a dividend signaling theory. However, partial adjustment hypothesis implies that dividends tend to lag behind earnings and the adaptive expectations hypothesis implies that dividends tend to lead earnings. See Ang [1] for details.

[2]Equation (10), instead of either equation (3) or equation (7), includes D_{t-2} as an explanatory variable. Equation (3) has α, λ and r to be estimated, and equation (7) has δ and r to be estimated. However, equation (10) has α, λ, r and δ to be estimated. In sum, both equations (3) and (7) can be regarded as a special case of equation (10).

[3]This statement is based upon an experiment with ten firms selected by their alphabetical order. We have found that on average Gauss-Newton's method uses .89 cpu second more than Marquardt's method for each regression estimate.

[4]Assume that the u_t follows the first order autocorrelation:

$$u_t = \rho u_{t-1} + \eta_t, \; \eta \sim \text{NID}.$$

Then v_t is normal white noise only if $\rho=(1-\delta)$. Otherwise v_t follows an ARMA (1,1) process as follows:

$$v_t - \rho v_{t-1} = \eta_t - (1-\delta)\eta_{t-1}.$$

[5]A list of the selected firms is available from the authors.

[6]Empirical results for the non-seasonally adjusted data are similar to those obtained from the seasonally adjusted data. They are available from the authors.

[7]Ang's [1] study can only be applied to quarterly data to test whether the dividend behavior is partial adjustment or information content. However, the model developed in this paper can be used to analyze both annual and quarterly data to determine the dividend payment behavior.

[8]The assumption of the normality of the stochastic disturbance term is less crucial for the nonlinear regressions. Malinvaud [16, pp. 325-341] has shown that even without the assumption of normality on the disturbance term, the asymptotic distribution of the nonlinear least squares estimates is normal and has the same mean and variance as the maximum likelihood estimates for the normal disturbance case.

[9]The Parks method has been used to estimate the cross-section time series regression coefficients. This method assumes a first-order autoregressive error structure with contemporaneous correlation between cross sections. The regressions coefficients were estimated using a program provided in SAS.

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